

Proposal summary

The proposed network brings together the Belgian expertise on theoretical and experimental nuclear physics, nuclear astrophysics and accelerator driven systems, and will execute, in a coherent and collaborative effort, a research program focussed around radioactive ion beam research. Together with the EU partners, a carefully selected sample of atomic nuclei most of them with extreme proton to neutron ratios will be studied to bring key elements for a better understanding of the manifestation of the strong, weak and electromagnetic interaction in the nuclear medium.

Key experiments on the properties of exotic nuclei through decay, moment and reactivity measurements are proposed while the beta decay of specific isotopes will serve the weak interaction studies. Theoretical studies are directed towards few-body models, mean field descriptions and shell models and their symmetries. The results will be used for nuclear-structure studies, weak interaction studies and nuclear astrophysics, as well as to investigate fundamental nuclear physics aspects of accelerator driven systems.

Based on the achievements and the expertise acquired from the present IAP network and in line with the international situation we propose a continuation of our research program whereby the importance of nuclear-structure research on and weak interaction studies with exotic nuclei increases substantially, neutron-capture experiments and an applied component related to accelerator driven systems are added.

The network has been extended with the experimental neutron physics group from U.Gent and the MYRHHA SCK•CEN group specialized in accelerator driven systems. New EU partners are the Institute of Nuclear Physics of the University of Köln, UNI Köln (Köln, Germany) and the Centre de Spectrométrie Nucléaire et de Spectrométrie de Masse, CSNSM (Orsay, France). These new partners bring novel expertise and re-enforce existing expertise in the network: high-level instrumentation for gamma-ray detection, in-beam spectroscopy, lifetime measurements, neutron physics, high-intensity proton radiation target stations, symmetry based nuclear modelling, mean-field calculations to name a few. The increased emphasis on exotic nuclei research and the embryotic study of some fundamental aspects of ADS has introduced a further reorientation of the program that was already initiated during the present phase.

An extended experimental campaign at the radioactive beam facilities of Louvain-la-Neuve (Belgium), ISOLDE-CERN (Switzerland), GANIL (France) and GSI (Darmstadt) and at the SCK•CEN and GELINA (Belgium) and ILL (France) neutron facilities is planned. Smaller campaigns at other facilities are foreseen as well. The major theoretical efforts will be closely related to the experimental work in order to stimulate mutual feedback between theory and experiment. This results in the research program that covers the following topics:

- Study of light exotic nuclei: structure, decay properties and reactivity: few-nucleon correlation effects, clusters structures, halo and skin structures
- Study of medium-heavy and heavy nuclei with a closed shell configurations for protons or neutrons: effective interactions in nuclei with extreme N/Z ratio, shape coexistence
- Study of nuclei along the $N=Z$ line: pairing correlations, deformation driving phenomena, exotic decay modes, $T=1$ and $T=0$ interactions, weak interactions

- Set-up effective interactions that will allow unrestricted shell-model studies for the largest possible model spaces in order to explore better the extremes of the nuclear shell model and an effective interaction, in the form of an energy density functional, in conjunction with a beyond mean-field method.
- Study of the nuclear physics aspects of reactions of astrophysics interest
- Study of rare actinides: nuclear structure, neutron-capture, accelerator driven systems

The proposed network lays down the Belgian research activities in nuclear physics to bridge the gap between now and the commissioning of the two major nuclear-physics facilities FAIR – GSI and EURISOL that are currently under construction/discussion in Europe. These activities will guarantee a continued visible role of Belgian research groups on the international scene of nuclear physics research.